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The Groundwater Remediation Field Laboratory (GRFL) at Dover AFB, DE is part of SERDP National Environmental Technology Test Sites program (NETTS), a tri-service and EPA network of sites for field testing innovative cleanup technologies. The GRFL is the Armstrong Laboratory contribution to the NETTS program. It is specifically focused on tehcnologies to deal with subsurface fuelds and solvents contamination, especially contamination by what are termed dense nonaqueous phase liquids (DNAPLs).

The GRFL represents the only place within the US where carefully planned experiments involving contained releases of DNAPLs can be carried out in the subsurface of an existing water table aquifer.

Demonstrations conducted at the GRFL must be of interest to the DoD, have sufficient peer review, and advance our understanding of DNAPL behavior in the subsurface or our ability to locate and cleanup these materials. Additionally, many of the demonstrations test technologies that can subsequently be utilized at Dover AFB on existing base contamination.

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INTERIM REPORT

GROUNDWATER REMEDIATION FIELD LABORATORY

Sponsored by:

SERDP

Prepared by:

United States Air Force
Armstrong Laboratory
Environics Directorate
Environmental Risk Management Technologies Division
139 Barnes Drive, Suite 2
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June 1997

GROUNDWATER REMEDIATION FIELD LABORATORY
GRFL
INTERIM REPORT FOR SERDP

EXECUTIVE SUMMARY

The Groundwater Remediation Field Laboratory (GRFL) at Dover AFB, DE is part of Strategic Environmental Research and Development Program (SERDP) National Environmental Technology Test Sites program (NETTS), a tri-service and EPA network of sites for field testing innovative cleanup technologies. The GRFL is the Armstrong Laboratory contribution to the NETTS program. It is specifically focused on technologies to deal with subsurface fuels and solvents contamination, especially contamination by what are termed dense nonaqueous phase liquids (DNAPLs).

The GRFL is important to the SERDP program, Armstrong Laboratory, and Dover AFB because it represents the only place within the United States where carefully planned experiments involving contained releases of DNAPLs can be carried out in the subsurface of an existing water table aquifer.

An extensive review of potential sites throughout the United States and a careful downselection to the most suitable site placed the GRFL at Dover AFB, DE. A professional, experienced environmental management staff at Dover AFB and a very favorable, proactive regulatory community within Delaware enhance the site's potential.

Armstrong Laboratory and the 436th Airlift Wing provide overall management structure for the site's operation. A site management team is maintained at Dover AFB and Tyndall AFB to manage ongoing demonstrations. The Armstrong Laboratory Environics Directorate developed the necessary infrastructure at the GRFL.

Infrastructure available to prospective researchers/developers includes the onsite management and monitoring team, regulatory and permitting interfacing, a peer review structure, unique contained release cells, full hydrogeological characterization of the site, limited laboratory capability, a remote data acquisition and control system, and SERDP-developed technology demonstration protocols.

Demonstrations conducted at the GRFL must be of interest to the Department of Defense (DoD), have sufficient peer review, and advance our understanding of DNAPL behavior in the subsurface or our ability to locate and cleanup these materials. Additionally, many of the demonstrations test technologies that can subsequently be utilized at Dover AFB on existing base contamination. Some demonstrations being conducted at the GRFL or planned for the near future include:

- **In Situ Co-oxidation of Chlorinated Solvents During Bioventing of Petroleum Hydrocarbons** - Armstrong Laboratory project with DoD/AATDF funding
- **Resistive Heating Demonstration** - Battelle Pacific Northwest Laboratories project with AF S&T funding
- **Enhanced Source Removal Demonstrations** - EPA NRML directed program with SERDP funding
- **Geophysical DNAPL Detection** - Colorado School of Mines project with AF S&T funding
- **Pulsed Pumping** - Johns Hopkins University and Waterloo University project with SERDP funding and follow-on AF S&T funds
- **Co-Metabolic Bioventing** - EPA NRMRL project with RTDF funding
- **Funnel and Gate** - Battelle Columbus Laboratories project with RTDF, AF S&T and SERDP funding
- **High Pressure Jet Grouting Demonstrations** - DOE Public/Private Partnership program with DOE & DuPont funding
- **Bioenhanced Vapor Stripping Well** - AFIT and Stanford University project SERDP funding
- **Cone Penetrometer Method for Measuring Hydraulic Conductivity in Unsaturated Soil** - University of South Carolina project with AFIT/ARO funding

The GRFL is selected as a site for the Rapid Commercialization Initiative (RCI), a federal interagency-interstate partnership designed to advance the rapid commercialization of viable new environmental technologies.

INTRODUCTION

The Air Force and other military departments use large quantities of solvents when working with precision equipment, electronics and other machinery. Past disposal practices have resulted in chlorinated solvent contamination of many areas on military bases. To the Remediation Program Managers solvent contamination is currently of secondary importance by volume when compared to fuels contamination of soil and groundwater. However, because chlorinated solvents are far less readily cleaned up in the environment, this type of contamination is becoming the single problem requiring the most extensive research into its monitoring, analysis, location and treatment. The Armstrong Laboratory, Environics Directorate, has assumed the Tri-Services responsibility for developing the GRFL test site for demonstrating the technologies needed in the future for solvent contamination treatment.

Chlorinated solvent contamination of soil and groundwater is much denser than water or other contamination in the subsurface, and does not easily degrade in the environment. In addition, although chlorinated solvents are only sparingly soluble in water, the concentration of solvent in contaminated groundwater is often sufficiently high to pose a

risk to public health and environmental quality. The GRFL concentrates on DNAPL contamination and features a potential for conducting experimental controlled releases of DNAPLs for technology development.

The term DNAPL is used to describe a number of materials, which are immiscible with, and denser than, water. As a result of these properties, they migrate downward when spilled on the ground, and can migrate below the water table. Especially once below the water table, they are difficult to locate and remove. For DoD, the term DNAPL is virtually synonymous with chlorinated solvents, used for years as industrial cleaners and degreasers, and responsible for the contamination at approximately one third of all Air Force contaminated sites as well as a large proportion of the contaminated Army and Navy sites. Currently there are no acceptable methods at any cost for removing or treating the bulk solvent material that sinks into aquifers or is trapped within soil interstices. These technologies must be developed to protect the public from the health risks associated with DNAPLs.

There are many contaminated sites around the country where field experiments are currently being performed. These field experiments provide excellent opportunities to verify some of the conclusions drawn from laboratory experiments. However, a number of hopefully valid assumptions must be made since experiments are being performed in previously contaminated aquifers. These assumptions include, but are not limited to, the amount and composition of contaminants introduced into the soil/water matrix, the exact location where the contaminants were introduced, and the initial conditions of the soil/water matrix prior to contamination. To eliminate the dependence on making such assumptions, it will be necessary to monitor the development of contaminant plumes from their inception while maintaining a mass balance of the contaminants. This information can be obtained only from well-planned, carefully contained experiments involving controlled/contained releases of DNAPL compounds. For this purpose, the Air Force established the Groundwater Remediation Field Laboratory as a national platform for research and development of innovative technologies to treat ground and groundwater contamination, especially DNAPLs.

The Groundwater Remediation Field Laboratory is at Dover Air Force Base (AFB), Delaware. The Air Force Armstrong Laboratory, Environics Directorate (AL/EQ), Tyndall AFB, Florida, developed the GRFL with major funding by the Strategic Environmental Research and Development Program. The GRFL is part of the tri-service demonstration program called the National Environmental Technology Test Sites program and is the NETTS site primarily geared toward demonstration of technologies for monitoring, measuring, and cleaning up DNAPL material. A major important feature of the GRFL is the provision of a capability to conduct contained releases of DNAPL material into a naturally occurring aquifer and manage the mass balance of contamination for select, carefully planned experiments.

The hydrogeology is composed of the Columbia (Pleistocene) Formation that forms a water table aquifer overlying the Calvert (Miocene) Formation. The lithology of the

Columbia Formation ranges throughout the State of Delaware from fine sand to coarse sand and gravel. In the area of Dover AFB, the Columbia Formation was deposited as broad sheet sands, and is found to be composed of medium to coarse sands with some silt and gravel. Pump tests in the area give hydraulic conductivities in the range of 2×10^{-5} cm/sec to 1×10^{-2} cm/sec and correlate with laboratory permeameter tests conducted on soil samples from the site.

At the GRFL, the depth to the clay aquitard is approximately 30 to 43 feet from ground surface. Depth to the water table is approximately 20-25 feet below ground surface. The resultant saturated thickness of the water table aquifer is between 33% and 60%. This will allow the raising of the water level within the annular space surrounding an experimental test cell to produce an inward hydraulic gradient.

The Columbia Formation in the Dover AFB area is relatively homogenous. The aquifer solids are composed of medium to coarse sands with varying amounts of silt and clay. This variation in silt and clay content produces subtle heterogeneities primarily reflected in groundwater flow rates ranging from 0.3 to 1.8 ft/day.

Water from the Columbia is generally "soft", slightly acidic, and characterized by low dissolved-solids content. High iron content and low pH are the only natural characteristics of the water that commonly require treatment.

The underlying Calvert Formation is composed of marine, estuarine, and delta plain silty clays, and forms an aquitard. Beneath Dover AFB, the thickness of this aquitard ranges among 18 and 28 feet, averaging 26 feet. The vertical hydraulic conductivity of this unit has been determined to range from 2.7×10^{-8} to 1×10^{-7} cm/sec. Groundwater flow rates have been calculated at 1.2×10^{-4} m/day. At this rate, groundwater from the Columbia would require 155 years to penetrate 22 feet into the aquitard (IRP Phase II).

Included in the Calvert Formation is the Frederica Aquifer, approximately 65 to 88 feet below ground surface. The Frederica Aquifer is a thin fine sand zone within the Calvert Formation. Little information is available on the Frederica aquifer as it is not used as a source of groundwater.

Regional water supply aquifers in the Dover AFB area are the Cheswold and Piney Point. The top of the Cheswold aquifer is approximately 175 feet below ground surface at Dover AFB, and is separated from the Frederica aquifer by approximately 85 feet of silty clays of the Calvert Formation. The top of the Piney Point aquifer is approximately 328 meters below ground surface at Dover AFB, and is separated from the Cheswold aquifer by approximately 267 feet of silty clay. In the Dover area, municipal supply wells are located up-gradient from Dover AFB.

Dover AFB has a continental climate with well-defined seasons. The Atlantic Ocean, Delaware Bay, and Chesapeake Bay exert considerable influence on the climate. The average annual precipitation is approximately 42 inches of rain and 17.1 inches of snow.

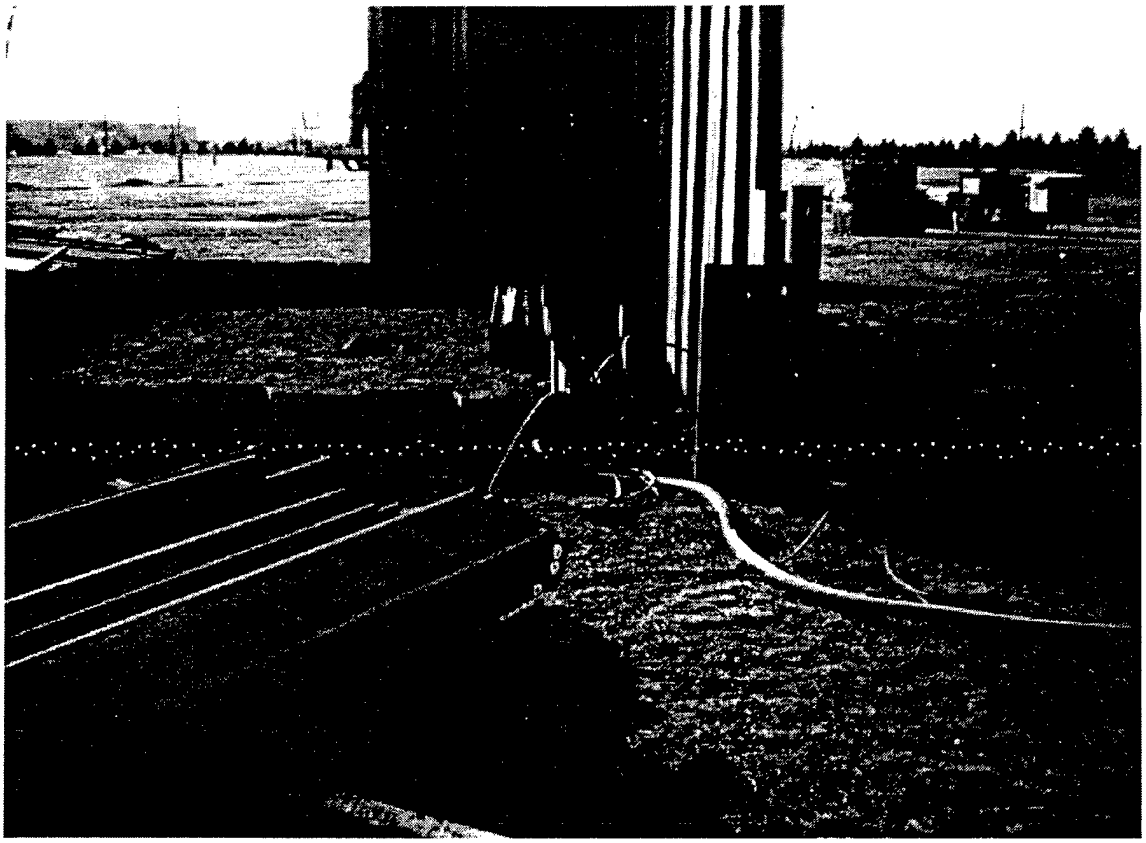
The monthly distribution is fairly uniform during the year; the wettest month is August with a monthly average of 4.67 inches of precipitation and February is the driest month with 3.10 inches of precipitation. The annual average relative humidity is 80 percent in the early morning and 57 percent in the late afternoon. The mean annual temperature for Dover AFB is 55.5 degrees Fahrenheit (degrees F) with the warmest month being July at 77 degrees F and the coldest month being January at 33 degrees F. Easterly winds off the Atlantic Ocean and Delaware Bay tend to raise the normal winter temperature and lower the normal summer temperature. The prevailing wind directions for Dover AFB are from the northwest (September to April) and from the southwest (May to August). The average annual wind speed is 6.2 miles per hour (mph) (USAF, 1993a).

The primary GRFL mission is to support research and development of innovative technologies intended to locate, characterize, and remove or destroy DNAPLs in soil and groundwater. A key feature of this facility is the ability to introduce DNAPL into the aquifer, so efforts to protect the public and environmental resources from potential harm, and especially to protect the groundwater resources of Delaware require a redundant containment and control system be constructed. The DNAPL is introduced only within the confines of a cell constructed of sheet piling. The sheet piling is manufactured to allow for jointing of one sheet to another, and the joints are tremie sealed with grout to ensure a tight, verifiable seal between sheets. By driving the sheet piling into the clay aquitard, a coffer is formed which prevents lateral migration outside the confines of the box. In addition to this primary coffer, a secondary containment coffer is constructed surrounding the primary coffer for each contained release cell, and will be similarly sealed at the bottom by the underlying clay and at each joint with bentonite. The annulus between the two cells is filled with water to ensure an inward hydraulic gradient, to further prevent unwanted releases of contaminant from the experimental chamber. The annulus is also continuously monitored for leakage of contaminant, providing opportunity to remove contaminants by emergency, backup pump-and-treat (carbon absorption) if necessary. A third protective regimen is monitoring wells outside the secondary coffer and downgradient from the chamber. The wells are constructed such that they too can be used in an emergency pump-and-treat system, if necessary.

APPROACH

Chlorinated solvent contamination poses one of the most challenging environmental cleanup problems facing the DoD. Currently, there are no acceptable methods, at any cost, to remove or treat the liquid solvent that sinks into aquifers or is trapped in the soil pores. Novel, innovative methods must be developed and adequately tested to protect the public from potential health risks posed by these contaminants.

SHEET PILING BEING INSTALLED AT GRFL - SPRING 1996



The GRFL differs from other demonstration programs in its emphasis on keeping a strict mass balance of the contaminants. Scientists can say for sure how effective a cleanup method is only if they know how much was there at the start. This is impossible at sites contaminated accidentally. At the GRFL, a known quantity of solvent is placed in the ground to test the cleanup method. Each test is conducted within test cells. Test cells are made of double walls of sheet piling, making an enclosed rectangle. Walls are sealed to prevent the solvent from leaking. Cleanup, monitoring and detection methods can be demonstrated side-by-side in the same soil, and be critically evaluated for their effectiveness in removing the solvent.

PROCEDURES

Armstrong Laboratory, Environics Directorate (AL/EQ) at Tyndall AFB, FL manages the GRFL at Dover AFB, Delaware. The GRFL is designed to support the needs of principal investigators developing and field-testing remediation technologies for the cleanup of soil and groundwater contaminated with fuels and solvents. The primary focus of the GRFL is demonstrating emerging technologies to remediate DNAPLs. Consequently, it maintains the capability to conduct contained releases of DNAPLs into a water table

aquifer for select demonstrations. This SERDP NETTS Site provides the following to a potential Principal Investigator (PI):

- **A well-characterized site for conducting permitted, in-situ, contained release experiments on the fate, transport, detection, monitoring, and remediation of fuels and solvents;**
  - Water table aquifer consisting of 9 to 13 m (30 to 43 ft) of fine to medium sands with some silt and gravel. Discontinuous clay lenses are present
  - Average hydraulic conductivity of $3x10^{-3}$ cm/sec (9.8 ft/day).
  - Depth to water of 7.9 m (25 ft).
  - Aquifer underlain by silty clay to clayey silt aquitard in excess of 8 m (26 ft) thickness
  - Average hydraulic conductivity of aquitard of $9x10^{-7}$ cm/sec ($2.5x10^{-3}$ ft/day)
  - Surface and borehole geophysical data (GPR, resistivity, EM-34, seismic)
  - Detailed soil physical, chemical and microbiological characterization
  - 3-D groundwater flow model

- **Double walled sheet pile test cells;**
  - Double walled cells with grouted joints keyed into underlying aquitard
  - Ability to adjust water levels within cell to accommodate specific test requirements
  - Induced hydraulic gradients possible
  - Groundwater treatment for recirculating water
  - Leak testing of cells prior to contained release experiments
  - Monitoring of cell integrity during experimentation

- **Well-characterized areas of existing fuels and solvents contamination;**

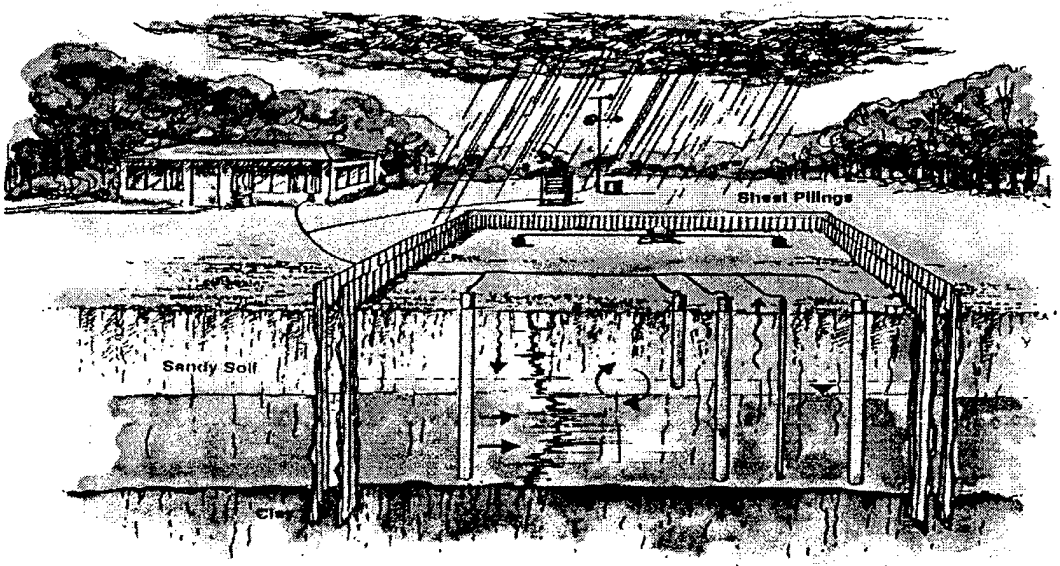
- **Onsite technical and administrative support;**
  - Office space for onsite and visiting personnel
  - Technical support for the design and preparation of field scale demonstrations
  - Peer reviewed templates for preparation of work plans, QA/QC plans, and H&S plans
  - Technical and administrative support for gaining regulatory approval
  - Technical and administrative support for developing memoranda of agreement (MOAs), test agreements, and cooperative R&D agreements (CRADAs)
  - Access to permitted solid and liquid hazardous waste handling infrastructure

- **Technical support infrastructure.**
  - Sample preparation laboratory
  - Onsite HP 6890 GC with head space analyzer, FID and ECD detectors, and analytical chemist support
  - Trailer mounted CPT system for soil and groundwater sampling, and well installation with onsite technical support
  - PC based data acquisition and control system for real time monitoring and control of field experiments
  - Treatment system for VOCs in groundwater and off-gases.

RESULTS AND CONCLUSIONS

The GRFL is a contained release facility for DNAPLs consisting of a maximum of five test cells spaced approximately 50 feet apart, and constructed and operated in a way to minimize the potential for environmental contamination. The basic design consists of interconnected, galvanized steel barrier piling sections (2 feet in width) forming a rectangular pattern. The sheet piling is manufactured to allow for jointing of one sheet to another, and the joints will be tremie sealed with bentonite grout to ensure a tight seal between sheets. By driving the sheet piling 3-5 feet into the clay aquitard (approximately 30 to 43 feet below the surface), a coffer is formed which prevents lateral migration outside the confines of the box. In addition to this primary coffer, a secondary containment coffer is constructed surrounding the primary coffer, and similarly sealed at the bottom by the Calvert clay and at each joint with bentonite. The annulus between the two cells is filled with water to ensure a hydraulic gradient inward, to further prevent unwanted releases of contaminant from the experimental chamber. The annulus is also continuously monitored for leakage of contaminant, providing opportunity to remove contaminants by pump-and-treat if necessary. A third protective regimen is monitoring wells outside the secondary coffer and downgradient from the chamber. The wells are constructed such that they can be used as an emergency pump-and-treat system, if necessary in an emergency.

GROUNDWATER REMEDIATION FIELD LABORATORY



GRFL Peer Review Committee:

GRFL operation involves a peer review committee accessible via electronic mail as proposals are received for projects to be included in the GRFL schedule. The Peer Review Committee is asked for opinion on the scientific merit of each proposed project. Membership is as follows:

Dr C. H. Ward
Energy and Environmental Systems Institute
Rice University

Dr Walter J. Weber, Jr.
Department of Civil & Environmental Engineering
The University of Michigan

Dr David Burris
Armstrong Laboratories/EQL

Dr Douglas M. MacKay
Adjunct Professor,
University of Waterloo Center for Groundwater Research

Dr Steve McCutcheon
US EPA Environmental Research Laboratory

Dr Karl Enfield
US EPA R.S. Kerr Laboratory

Dr Quentin Skinner
Center for Environmental Simulation Studies
University of Wyoming

DAFB Installation Restoration Technical Review Committee:

The established Dover AFB Installation Restoration Technical Review Committee (TRC) has membership from Armstrong Laboratory, Dover AFB Environmental Flight, HQ Air Mobility Command, Delaware Department of Natural Resources and Environmental Control, and EPA Region 3. The TRC acts as a general, technical steering committee. The Steering Committee will propose general guidance on the operation of the GRFL, but the government project officer, the base Environmental Coordinator and the relevant state and federal regulators will set GRFL policy and develop the test agenda.

Support Negotiated From Dover AFB:

Armstrong Laboratory is a tenant organization on DAFB for the purpose of operating the NETTS facility. A support agreement delineates the support to be provided to the GRFL as a tenant organization. This support represents significant cost savings to SERDP, the GRFL effort and all projects supported. It includes:

- 24 hour weather services; forecasting, data collection
- Vehicle support including fueling, maintenance, repairs as needed
- Provide all normal utilities including water, sewage, electricity, and other utilities
- Supplies and Procurement for common expendable office supplies
- Use of Hazardous Waste Pharmacy
- Shuttle Services , U-Drive It services, base taxis
- Safety Program Support, occupational safety and health training, mishap investigation, consultant support
- Refuse Collection and Disposal
- Public Affairs guidance, clearance, interface with media
- Police Protection, security consultation, vehicle pass & identification
- Permit access to bases fitness centers, gyms, recreational centers, athletic fields, libraries, hobby shops, craft centers
- Billeting Accommodations
- Provide emergency medical treatment
- Fire protection, consultation, training
- Travel voucher support
- Facility maintenance and minor repair
- Facility construction and CE support as required
- Environmental coordination, permitting, interfacing

- Management of hazardous waste collection
- Pest management services
- Provide telephone lines

DISCUSSION

Several Demonstrations are in place, ongoing or planned for the near future at the GRFL. The following is a short summary of current status for each.

- In Situ Co-oxidation of Chlorinated Solvents During Bioventing of Petroleum Hydrocarbons - This is a contained release project, with a permitted release of 90 liters aged jet fuel with 10 liters trichloroethylene in the vadose zone. Project is funded by the Advanced, Applied Technology Demonstration Forum (AATDF) through Rice University, managed by Ms Cathy Vogel of AL/EQ and Dr. John Wilson of the EPA. Field operation began May 1996 with a final coring campaign in June 1997. The effort is important since it investigates the use of bioventing to aerobically degrade a mixture of jet fuel and trichloroethylene such as would commonly be encountered in abandoned Air Force fire fighter training pits.

- Resistive Heating Demonstration - This demonstration investigates the use of six-phase electrical resistive heating to raise the temperature of the soil and groundwater to boiling, creating an in situ source of steam to strip contaminants. Solvents and fuels in the soil and groundwater are volatilized and extracted by vapor extraction technology. The field test was conducted in an uncontaminated aquifer using tracer compounds to mimic DNAPLs. Captain Jeff Stinson and Major Paul DeVane of AL/EQ manage this demonstration. Battelle Northwest Laboratories is the performing organization. The draft final report submitted June 1997.

- Enhanced Source Removal Demonstrations - This is a SERDP-funded, three year series of demonstrations being managed by Major Paul DeVane of Armstrong Laboratory and Dr. Karl Enfield of the EPA to demonstrate new innovative chemical flushing techniques for removing the DNAPL sources of groundwater contamination, thereby lowering the overall costs for cleanup. Two containment cells are in place for this series. Permitting actions are underway and the first of six contained release demonstrations is to begin in the summer of 1997.

- Geophysical DNAPL Detection - This is an AF funded project to evaluate several geophysical techniques side-by-side to locate and monitor released DNAPL migration in the subsurface. Captain Michael Geer of Armstrong

Laboratory and Dr. Gary Oelhoft of the Colorado School of Mines manage the project. Estimated start of field work is September 1997.

- Pulsed Pumping - This SERDP funded study evaluates the effects of intermittently turning off a pump-and-treat system which has reached a contaminant concentration asymptote, then restarting the system when the groundwater concentrations have rebounded. Initial results of this effort show that pulsed pumping may achieve similar cleanup levels in the same time frame as conventional cleanup regimes with some potential cost reduction. Dr Doug Mackay, the University of Waterloo and Dr William Ball, Johns Hopkins University, are the investigators, and Ms Alison Thomas, Armstrong Laboratory is the program manager. Initial field work is complete and a draft report is being reviewed. Publication is expected late in FY 97. Study of DNAPL contaminant rebound continues for 1997 under AF S&T funding with a separate report to follow.

- Co-Metabolic Bioventing - The Remediation Technologies Demonstration Forum (RTDF), a consortium of industrial, academic and governmental parties, has chosen Dover AFB for demonstration of the use of bioventing to cleanup soil and groundwater by injecting air and a carbon source (i.e. propane) to enhance degradation. Dr. Greg Sayles of the EPA is the Principal Investigator. Site characterization and treatment system installation has been competed. Demonstration will begin mid summer 1997.

- Funnel and Gate - The use of iron filings and other reactive media for the passive in situ treatment of chlorinated solvents in groundwater will be studied, beginning spring 1997, in a funnel and gate system at Dover AFB. This project involves AF S&T and SERDP funding, Armstrong Laboratory (Lt. Dennis O'Sullivan) management, with RTDF in-kind technical support provided by several industrial partners. Site characterization and construction scheduled for June 1997. Monitoring of the emplaced gate and down gradient wells will continue for approximately one year. Long term performance monitoring will be accomplished with help from the Dover AFB Civil Engineering Environmental Flight.

- High Pressure Jet Grouting Demonstration - A public-private partnership called the DOE Barriers Group will be testing cost effective impermeable barrier technologies at the GRFL. High pressure jetting will be the technology to be demonstrated in three phases over two years. Phase I, a proof-of-principle demonstration, began May 1997. The second phase involves the construction of a deep jet grouted box to be leak tested with geophysical techniques performed to verify integrity. If this technology proves viable for the construction of contained release cells, a test cell for contained releases

using high pressure jet grouting will be constructed. A more feasible application for this technology is for installing funnel and gate barriers.

- Bioenhanced Vapor Stripping Well - This demonstration is SERDP funded, due to begin at the GRFL in the winter of 1997, and is managed by Dr. Mark Goltz of AFIT and Dr. Perry McCarty of Stanford University. The demonstration involves a combination of two *in situ* treatment technologies placed in series; an in well vapor stripper to remediate a DNAPL "hot spot zone" upgradient from a biotreatment well to polish up the lower concentrations left behind.

- Cone Penetrometer Method for Measuring Hydraulic Conductivity in Unsaturated Soil - Hydraulic Conductivity of soil in the unsaturated zone is a controlling factor in the transport of water-borne contaminants to groundwater, and as such, accurate assessment of its value is essential for site characterization and remedial design purposes. Air Force Institute of Technology through the Army Research Office is currently supporting the University of South Carolina in the development of a prototype in situ method for measuring hydraulic conductivity. Dr Molly M. Gribb is the Principal Investigator. Several field tests are planned for at least one year, beginning in April 1997.

Technology transfer and marketing for this site is necessarily focused at both the specific technology developers (users of the site) and those remediation program managers who are most aware of the DNAPL problems the DoD has and the serious need for innovative fixes to the problem (users of technology).

- Trade, scientific, news, & DoD publications:
  - Smith, Mark H., Paul Kerch and Alison Thomas. 1996. *GRFL Research Opportunity.* Military Engineer, Vol. 88, No 579, Pg. 49-50.
  - Shannon, Daniel. 1996. *First U.S. Controlled Release Site Opens To Test Technologies At Dover Air Force Base.* Environmental Science & Technology/News, Vol. 30, No. 8, Pg. 334.
  - Applied Research Associates, Inc. 1996. *Groundwater Remediation Field Laboratory - GRFL: Hydrogeology Characterization and Site Development. Draft AL/EQ Technical Report.* 2 Vols. 192pp.
  - June 1996. *Unique Field Laboratory To Research Planned Aquifer Releases.* EPA Groundwater Currents, Issue No. 15, Pg. 1.
  - Applied Research Associates, Inc. 1996. *Case Study: Integrating Surface Geophysical Methods With Cone Penetration Testing Techniques.* CPT Industry News, Vol. 1, No.3, Pg.3.
  - Mouche', Carol. March 97. Federal Focus - Researchers Invest a Little, Gain a Lot at Federal Field Labs. Pollution Engineering, Vol29, No.3, Pg46.

-Others

- DOD/NETDP SERDP Tri-Fold
- GRFL Tri-fold
- Tech Payoff (attached)
- Technology Summary Sheet (attached)

-Presentations/Poster sessions

- Technology and Business Exchange Symposium, June 1995, Huntsville, AL
- SERDP Symposium, September 1995, Washington, D.C.
- Tri-Services Environmental Technology Workshop, May 1996, Hershey, PA
- Aerospace Environmental Technology Conference, August 1996, Huntsville AL
- Symposium on Natural Attenuation of Chlorinated Solvents, September 1996, Dallas, TX
- EESI's 2nd Annual Symposium on Energy & the Environment (Sponsored by the Advanced Applied Technology Demonstration Facility, September 1996, Houston, Texas
- EPA Federal Remediation Technologies Roundtable, September 1996, Washington, D.C.
- 3rd International Symposium on Environmental Contamination in Central and Eastern Europe, September 1996, Warsaw, Poland
- SERDP Symposium, October 1996, Washington, D.C.
- U.S./German Data Exchange Agreement meeting, October 1996, Koblenz, GE
- World '96 Environmental Congress, October 1996, Cincinnati, OH
- 1997 International Containment Technology Conference and Exhibition, February 1997, St Petersburg, FL
- Fourth International Symposium, In Situ and On-Site Bioremediation, April 1997, New Orleans, LA

-Tours and Distinguished Visitors

- Distinguished Visitors hosted include Mr. Tad McCall, Under Secretary of Defense for the Environment; General Lupia, AF Civil Engineer; Mr. Walt Kovalick, Director of EPA Technology Innovation Office; General Cross, Commander Air Mobility Command; Mr. Mike McCabe, EPA Region III Administrator; attendees for the NATO Partnership for Peace Mtg.; East European Ministers of Environment; members of Dutch EPA. The NATO Committee on Challenge for Modern Society will visit in February.
- Commercial Organizations involved at, or who have visited the GRFL include General Electric, Battelle Memorial Institute, Clean Sites, Dow Chemical, DuPont Chemical Corp., EMCON Corp., Environmental Technologies, Geometrix, ICI Americas, Monsanto, Zeneca, OHM, Woodward-Clyde, ARA, BDM, PRC, Dames & Moore, Envirogen among others
- Governmental Entities involved or who have visited the GRFL include:
    - U.S. Air Force - AFOSR, Phillips Laboratory, AFCEE

- U.S. Army - Waterways Experimentation Station, Army Environmental Center
- Department of Energy - INEL, ORNL, PNL, Sandia, SRL, LBL, LLNL
- Environmental Protection Agency - National Exposure Research Laboratory, National Risk Management Laboratory, Technology Innovation Office, EPA Region III
- States - Delaware Geological Survey, Delaware Department of Natural Resources and Environmental Control, Pennsylvania Department of Environmental Protection

- Universities - University of Delaware, Delaware State University, Johns Hopkins University, University of Waterloo, University of Michigan, University of Tennessee, University of Florida, University of Oklahoma, Clemson University, University of Texas, Rice University, New Mexico Technological University, State University of New York - Stony Brook, Virginia Technological University, University of Wyoming, Georgia Tech University, Penn State University, University of Virginia, University of South Carolina, Air Force Institute of Technology.

-Miscellaneous/Awards

- Named as one of six sites in the U.S. as Environmental Technology Test Beds for the Rapid Commercialization Initiative of the U. S. Depts. of Commerce, Defense, Energy, U.S. EPA, California Environmental Protection Agency, Southern States Energy Board, and Western Governors' Association, August 1996
- Special Recognition Award given to Dover AFB and the GRFL by EPA Region III Administrator, October 1996

-Future Marketing Plans

- Continue to market through papers and presentations
- Consulted with The Gulf Coast Alliance for Technology Transfer (GATT) to prepare a long term marketing strategy for the GRFL.